Performance of Sound Insulation in Buildings — A Case Study

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The purpose of this study is to recognize usual facade sound insulation problems that affect a construction's acoustical quality by measuring the facade's sound insulation. Thirteen different situations were evaluated through in situ measurements in Curitiba, Brazil. By measuring buildings in different locations with constructive materials and different designs, this research found that the performance of the majority of evaluated facades did not reach the minimum proposed by both Brazilian and Portuguese standards. These results indicate that the sound insulation quality in Brazilian buildings is low and is mainly due to constructive imperfections and the use of materials with unfavorable acoustical properties.

1. INTRODUCTION

Recent studies have found that, like other Brazilian metropolises, Curitiba is acoustically polluted.[1–7]The solution to this environmental problem involves control by means of technical, political, and educational actions. One of the main tools available to ensure adequate sound pressure levels inside buildings is the sound insulation of their facades. Like so many other branches of engineering, sound insulation design requires dedicated study to reach established goals and to correct nonconforming situations by taking into account the management of various resources (e.g. financial, time, labor, materials, etc.).

Previous studies suggest builders were negligent with the acoustical quality of Brazil's building facades. Based on statistical surveys, Jobim claimed that the lack of acoustic comfort is a major source of dissatisfaction among home owners.[8] According to Queiroz and Viveiros, the quality of sound insulation of frontal facades in Brazil declined significantly between 1968 and 2005.[9] All the homes assessed by Ferreira and Zannin in Curitiba presented sound insulation values that did not meet the German standard DIN 4.109 "Schallschutz im Hochbau".[10,11]

Thirteen different situations of facades were evaluated in situ in Curitiba, state of Paraná, according to the parameter of weighted standardized level difference — $D_{2m,nT,w}$. The results were compared with the Brazilian standard NBR 15.575 "Edificações habitacionais Desempenho" and Portugal's Building Acoustics Regulations — RRAE "Regulamento de Requisitos Acústicos de Edificações".[12,13] Gaps of approximately 0.5 cm in length were left deliberately in three facades in order to study their effect on the sound insulation of the buildings.

2. METHODOLOGY

Sound insulation measurements were taken in thirteen situations at different building facades (e.g. apartments, homes and classrooms) in various parts of Curitiba. Several situations were addressed and took different building materials into account.

The measurements were taken according to the global method described in the standard ISO 140-5 "Acoustics Measurement of sound insulation in buildings and of building elements".[14] The loudspeaker and traffic noise methods were used according to the most suitable one for each situation. Internal sound sources (e.g. neighbors and household appliances)were not considered, since measurements were taken in quiet conditions. The measured parameter was the standardized level difference $D_{2m,nT}$, in the 100 to 3150 Hz frequency range. Then, the procedure described in the standard ISO 717-1 "Acoustic Rating of sound insulation in buildings and of building elements Part 1: Airborne sound insulation" was used, which allowed the team to obtain a single value for sound insulation performance (i.e. the weighted standardized level difference), $D_{2m,nT,w}$.[15]

This single value represents the result of the measurement of acoustic parameters taken in octave or one-third octave frequency bands. This value was used as the criterion to compare the measured values and those established by Brazilian and Portuguese standards (NBR 15.575 and RRAE, respectively).

The standardized level difference, $D_{2m,nT}$, is given by:[14]

$$D_{2m,nT} = L_{1,2m} - L_2 + 10\log\left(\frac{T}{T_o}\right); \qquad (1)$$

where:

$D_{2m,nT}$ – standardized level difference measured 2 m away from the facade, dB;

$L_{1,2m}$ – external sound pressure level 2 m away from the facade, dB;

L_2 – indoor average sound pressure level, dB;

T – indoor average reverberation time, s;

T_o – indoor reference reverberation time value, = 0,5 s, s.;

The parameters $L_{1,2m}$ and L_2 were measured simultaneously by using two microphones, a dual channel adapter, and a flat cable. This flat cable could be passed through an element that separates the facade (door or window) even when it was closed. This was necessary because if a cylindrical cable was used, a crack would have had to be left open in the separating element, which would have impair the accuracy of the measurement of the sound insulation, thus underestimating its levels.[14] All data was collected in the afternoon over the course of several days and, although the equipment set up time was long, each measurement lasted for only a few seconds.